VI.—*Variations of Rainfall in Northern India during the Sunspot Period.*—*By* A. N. Pearson, Esq., *Officiating Meteorological Reporter for Western India. Communicated by the* President.

[Received October 6th;—Read November 5th, 1884.]

(With Pl. XI.)

Mr. S. A. Hill, in his paper on the "Variations of Rainfall in Northern India," published in the *Indian Meteorological Memoirs*, Vol. I, showed very clearly the opposition that exists between the variations of the winter and of the summer rainfall in Northern India during the sunspot period. For the purpose of bringing forward with greater clearness the main points of his investigation, he put the actual rainfall totals—which, as they stood, showed considerable apparent irregularities—through a simple process of smoothing such as is frequently adopted in dealing with statistical tables; and, by so doing, eliminated the apparent irregularities. But it appears to me that the unsmoothed results present points of interest over and above those that are presented by the smoothed results; that, in fact, the apparently irregular variations are regulated in a very definite manner.

In the table here given, I reproduce the general means of Mr. Hill's Tables II and IV, together with the smoothed results as he gave them in the text.

Variations of the Rainfall for each Year of the Eleven Year Cycle in Percentages of the Local Means.

Year of the Cycle.	Winter Rainfall.			Summer Rainfall.		
	Unsmoothed.	Smoothed.	Difference.	Unsmoothed.	Smoothed.	Difference.
1st	— 17·6	— 17·1	— 0·5	+ 0·8	+ 3·6	— 2·8
2nd	— 4·6	— 13·6	+ 9·0	+ 12·7	+ 7·4	+ 5·3
3rd	— 25·6	— 18·8	— 6·8	+ 3·3	+ 9·8	— 6·5
4th	— 19·5	— 20·4	+ 0·9	+ 19·8	+ 12·6	+ 7·2
5th	— 17·0	— 7·8	— 9·2	+ 7·4	+ 7·8	— 0·4
6th	+ 22·1	+ 23·1	— 1·0	— 3·5	— 5·6	+ 2·1
7th	+ 65·4	+ 35·6	+ 29·8	— 22·7	— 10·8	— 11·9
8th	— 10·4	+ 15·7	— 26·1	+ 5·6	— 8·1	+ 13·7
9th	+ 18·3	+ 10·2	+ 8·1	— 21·0	— 10·0	— 11·0
10th	+ 14·9	+ 4·9	+ 10·0	— 3·6	— 7·0	+ 3·4
11th	— 28·6	— 14·9	— 13·7	+ 0·2	— 0·6	+ 0·8

The smoothed numbers of the above table are curved in the accompanying diagram (Pl. XI) in thick continuous lines, under the names "Winter Rainfall, A" and "Summer Rainfall, B." The figures so produced are identical with the curves given by Mr. Hill in his paper. The unsmoothed numbers of the above table are in the diagram superposed in dotted lines upon the smoothed curves. At the bottom of the diagram, I have reproduced the sunspot curve as given by Mr. Hill.

On inspecting the smoothed rainfall curves, it will be seen that the winter and the summer curve both agree in showing a single oscillation during the eleven years of the sunspot period; but they differ in the character of that oscillation, for, while the winter rainfall is at its maximum during the year of sunspot minimum, the summer rainfall on the contrary is then at a minimum. This is the main fact pointed out in the paper above quoted.

On inspecting the actual figures, however,—the unsmoothed numbers in the above table and the dotted curves A and B of the diagram—it will be seen that, besides this eleven yearly oscillation, both the winter and the summer rainfall show several variations of minor period such as one might naturally suppose to be accidental; thus the winter rainfall shows three distinct maxima, one in the 2nd year of the sunspot cycle, one in the 7th year, and one in the 9th and 10th, and shows marked minima in the 3rd, 8th, and 11th years; while the summer rainfall has maxima in the 2nd, 4th, and 8th years and minima in the 3rd, 7th, and 9th.

It is to these minor period oscillations that I wish in this short paper to call attention. And, in order that they may present themselves in a more convenient form for study, I have separated them from the eleven yearly oscillation by the simple method of subtracting the smoothed numbers in the above table from the unsmoothed. The differences are curved in the diagram under the name "Minor Oscillations of A and B," the winter oscillations being given in dot-and-dash lines, and the summer in simple dotted lines.

Confining attention to these "minor oscillations" curves, it will be noticed that, in those years which at the foot of the diagram are marked +, and which are years of maximum sunspot, the short period oscillations in the winter and the summer rainfall are of the same character, that is to say, that when there is more winter rain there is more summer rain, and when there is less of the one there is less of the other also. But it will be seen that, in those years which at the foot of the diagram are marked —, and which are years of minimum sunspot, the short period oscillations in the winter rainfall are of opposite character to those in the summer rainfall, that when there is more rain in the winter there is less during the summer, and *vice versâ.* Again, in those years which in the diagram are marked $\pm$, and which immediately precede the years of sunspot maximum and minimum, the order above pointed out obtains only in a slight degree ; in other words, these are years of transition.

That these facts are purely the result of accident seems very unlikely, for they are supported by three other series of concurrent facts ; which are as follow :—

1st. The *plus* years begin immediately *after* the sunspot maxima, and the *minus* years begin immediately *at* the sunspot minimum.

2nd. There are more transition years during the slow descent of the sunspot curve than during its rapid ascent.

3rd. The oscillations of both the winter and the summer rainfall are of greater amplitude during the *negative* years than during the *positive.*

With reference to the first of the above series of facts, it might be supposed that, as the *minus* years begin immediately *at* the sunspot minimum, so for perfect analogy the *plus* years should begin immediately *at* the sunspot maximum. But this is by no means necessary, for the slight delay in the coming in of the positive years agrees very well with the slow descent of the sunspot curve as compared with its rapid ascent.

The main fact which I have pointed out in this paper,—namely, that the smaller variations of the winter rainfall are the same in character as those of the summer rainfall during years of maximum sunspot ; and opposite in character during years of minimum sunspot,—if it can be established as a general rule, will be an important one ; for it will indicate that, whatever be the cause which produces the general opposition in character between the eleven yearly variations of the winter and of the summer rainfalls, that cause operates chiefly during the years of minimum sunspot, and during three years of maximum sunspot it operates only in a very minor degree, and in two of those years (namely, the 1st and 2nd) it probably does not operate at all. By thus limiting the period during which the cause operates, a valuable point is gained, and a clue to a knowledge of the cause possibly afforded.

It is also interesting to notice that not only do the rules above indicated obtain *qualitatively*, but that there is also a near approach to a *quantitative* relation between the short period oscillations of the summer and the winter rainfall respectively. The nature of this relation in the years which I have denoted as *positive*, namely, in the 1st, 2nd, and 3rd years of the sunspot cycle, will be seen at once on inspecting the " minor oscillations " curve of the diagram. It will be observed that the oscillation which takes place in the two curves during those three years is not only the same in phase, but is nearly the same in amplitude. The fact can be expressed numerically by taking the percentage rainfall as given in the "Difference" columns of the above table; when it will be seen that the winter rainfall of the 2nd year was 16·3 heavier than during the 1st and 3rd years taken together; while the summer rainfall was 14·6 heavier. The numbers 16·3 and 14·6, which according to this method are a measure of the excess of the winter and the summer rainfall respectively during the 2nd year, approach each other sufficiently to be noticeable.

The nature of the quantitative relation during the negative years, namely, the 7th, 8th, and 9th, will be best seen by an examination of the actual rainfall of those years. This, obtained from Mr. Hill's Tables I (A and B) and III (A and B), is as follows :—

Year of the Cycle.	Winter Rainfall.			Summer Rainfall.		
	Hills.	Plains.	Mean.	Hills.	Plains.	Mean.
	inches.	inches.	inches.	inches.	inches.	inches.
1st	17·95	6·30	12·12	41·81	26·36	34·08
2nd	9·58	3·23	6·40	54·01	34·63	44·32
3rd	16·55	4·59	10·57	47·13	27·03	37·08
Average of the three years.			9·70			38·49

Dealing only with the mean results, the variations in each year from the three years' average are in the case of the summer and the winter rainfalls respectively as follows :—

	7th year.	*8th year.*	*9th year.*
Winter	+ 2·42	— 3·30	+ 0·87
Summer	— 4·41	+ 5·83	— 1·41

Now the point to be noticed is that

$$2{\cdot}42 : 4{\cdot}41 :: 3{\cdot}30 : 5{\cdot}83 :: 0{\cdot}87 : 1{\cdot}41,$$

or very nearly so; the winter figures to be in exact proportion should be 2·53, 3·34, and 0·81; but the approach to exactness is sufficiently near to be striking, and to make one suspect that there has been something more than chance at work in its production. If this proportion can be established as a general rule, it will signify that, during the three years at, and immediately succeeding, the sunspot minimum, an excess of 1 inch in the winter rainfall is accompanied by a defect of about 1·74 inches in the summer rainfall, and a defect of 1 inch during winter is accompanied by an excess of 1·74 inch during summer.

It is not my intention, for the present at least, to seek out the full meaning of these facts ; indeed, it is scarcely within my province to do so, as the investigation is already in more experienced hands than mine. But the facts forced themselves on my notice, and they seemed of sufficient importance to justify their publication.

VII.—*Description of a new Lepidopterous Insect belonging to the Heterocerous Genus* Trabala.—*By* F. Moore, F. Z. S., A. L. S. *Communicated by the* Natural History Secretary.

(Received August 26th ;—Read December 3rd, 1884.)

Trabala irrorata, n. sp.

♀. Upperside dark olivaceous ochreous-yellow, sparsely speckled with dark purple-brown scales, which are most numerously disposed on the exterior border, and sinuously across the inner disc of both wings and also subbasally across the forewing, as well as on the posterior border of the forewing. Both wings with a discal transverse zigzag series of large lilacine-grey spots, which are also thickly speckled with the dark brown scales ; forewing also with the posterior border blotched with lilacine-gray, and with a prominent lilacine-gray spot, with dark brown speckled border, in the middle of the cell. Cilia entirely yellow.

Underside slightly paler than the upperside ; both wings with the discal zigzag spots as above, the exterior borders less sparsely speckled with brown scales ; a slight brown-speckled sinuous discal band also on the hindwing ; cell-spot indistinct.

Body brighter yellow, and tuft lilacine-white.

Expanse $3\frac{1}{4}$ inches.

Hab. Mergui. Collected by Dr. J. Anderson, F. R. S.